Impact of Natural and Artificial Phenomena in Coastal Modification – A Study on Digha Coastal Region, West Bengal

Dr. Sanghamitra Adhya
Assistant Professor in Geography
Kalyani Mahavidyalaya
West Bengal, India

Digha is West Bengal's most popular sea resort. It is situated in the south-east corner of the Purba Medinipur district and at the northern end of the Bay of Bengal.

Digha Planning Authority was initially constituted in the year 1990 with 16 mouzas as its planning area. Later on its area was extended up to 42 mouzas (17 mouzas are in Rannagar P.S. and 25 mouzas are in Digha P.S.). Subsequently the Planning Authority was transformed into Digha Development Authority with effect from 19.12.1993. The nomenclature of the Authority has been changed from Digha Development Authority to Digha Sankarpur Development Authority (DSDA) with effect from 15.7.2004. The study area covering these 42 mouzas is located within $21^{o}30^{/}$ - $21^{o}36^{/}50^{//}$ N. and $87^{o}29^{/}40^{//}$ - $87^{o}37^{/}$ E. The length of this area is 14 km and width varies from 2.5 - 3 km from the Low Tide Level. The total area of this region is 35.43 sq. km.

Physical Background

Coastal zone is a broad transitional area between the land and sea. The shoreline is a boundary line between land and sea. Because of its dynamic nature, the shoreline changes gradually. This change is provided by sequences of storms and cyclones, coastal processes, sea level rise, and seismic events, involving a specific range of space and time.

The geological history of the coast is relatively short and the coast is still in its formative state. Its present day condition is the result of fluvio-tidal and coastal processes resulting from the onlapping sequence of Flandrian transgression,>5900 years B.P. and offlapping sequence of delta progradation till the stabilization of the sea level at around 3000 years B.P. C_{14} dating of the coast showed that this stretch of beach was 2920 ± 160 years old. The bathymetric chart reveals that the general offshore gradient ranges between 1: 001 to 1: 003.

The elevation of this region is 0-3 m above sea level. The beach material is generally siliciclastic quartzo-feldspathic in composition with well sorted, medium to fine sand. The estuarine mud is found in many places mixing with the beach sand which creates mixed flats. The Digha beach is dominated by sedimentation from the Subarnarekha river. Depending on the present state of erosion-accretion the entire region falls under erosional regime.

Natural Causes of Coastal Erosion

i. Strong Tides : The mean range of tide during spring at Digha is 4.2m. The destructive power of revolving tropical cyclones with strong S.W. monsoon hits the Digha coastal tract (8-10 times) during the mid rainy season. In this period the joint hazards of winds (8 - 17 km/ hr), waves (4 - 7 m high) and tides rise up to 5 - 6m cause greatest erosion (Table 1).

Table 1: Characteristics of Sea Waves in Digha Coastal Region

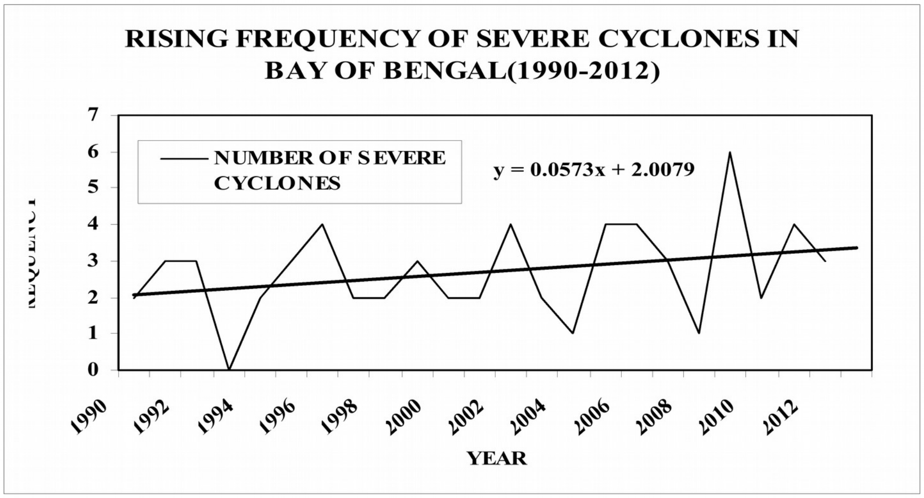
STATION	MONTH	WAVE VELOCITY (M / SEC)	WAVE LENGTH (M)	WAVE HEIGHT (M)	WAVE STEEP-NESS	WAVE ENERGY	BREAKER TYPE
DIGHA	JAN-FEB	5 TO 6	15 - 22	0.7 - 4.9	.05 - .04	MEDIUM	PLUNGING
	AUG-SEP	6 TO 8	30 - 40	4.8 - 6.5	.03 - .04	HIGH	PLUNGING

Source of Data: Based on Field Survey 2008-2013

ii. Sea Level Changes : The relative mean sea level computed from the tide data of Digha –Sankarpur, collected by the Department of Irrigation, Govt. of West Bengal while formulating the Integrated Coastal Zone Management Plan shows a rising trend since 1990. The rate of relative sea level rise is found to be over 3mm/year and this makes some contribution to the coastal erosion. Recently, a large part of the coastal stretch from Old Digha to Sankarpur suffered significant damage (about 150 m stretch) due to devastating tidal surge. Already 9 mouzas (village clusters) have been depopulated along the 13 km coastal segment.

On many parts of the coast, sand is continually being brought on to the shore by the advancing waves. In the neighbourhood of high-water mark the shore soon becomes dry, and the sand is then borne landwards by any wind coming from the sea. Where the sand accumulates faster than it is being blown away, a hill, or a dune as it is frequently called, is formed. Any obstacle in the path of the blown sand will also arrest its progress and cause it heaping up. Frequently the dunes are very unstable, and in some places so much so that great areas of moving sand exist. These 'wandering dunes', insidiously advancing inland, do great damage-burying fertile fields, filling up flax swamps, choking watercourses, and overwhelming forests, plantations, pasture lands, and even dwellings. Originally nature had done much to stop such inroads, and the wandering dunes of Digha coastal area are chiefly the result of damage done by construction of settlement, hotels, grazing animals through breaking the surface of the sand, and by destroying the natural safeguard, its plant covering.

iii. Severe Cyclonic Storms: Wave climate is moderate excepting periods of cyclonic storms when a wave height may reach upto 7m. There is a rise in high intensity events like severe cyclonic storms and consequent damage and flooding in and around Digha Coastal region (Fig. 1). Scientists from Indian Meteorological Department has observed a 26% rise in the frequency of high to very high intensity cyclones over the last 120 years. Dune erosion due to these cyclonic storms results landward retreat of the beach, lowering the beach profile and loss of dune vegetation.



Source of Data: Regional Meteorological Centre, Kolkata

Fig. 1

Many planted areas are uprooted by wave attack. There were incidents of such severe storms in the recent past during the years 1987, 1997 and 2002 when the seawall was heavily destroyed along with extreme damage of the beach side road. The November 12, 1997 cyclone caused a havoc devastation of the coast bringing about massive damage. There were incidents when hundreds of fishing trawlers were capsized causing deaths of hundreds of fishermen. Dunes and embankments were damaged and breached at places. Dwelling and agricultural lands of many coastal families were totally eaten up by the sea. In the year 2009, the severe cyclone 'Aila' hit the State of West Bengal with 120 km/ hr wind speed and around 2 m high storm surge.

iv. Biogenetic Activity: Biogenic activities in the soft-bottom sediments in the form of bioturbation structures by the macrozoobenthic groups are common in the beach (*E. coli*, *E. vibrio Salmonella, Shigella, Pseudomonas, Aerugenosa*, *Streptococcus faecalis* etc). They move both surficial and internal sediments up to a depth of 1m by burrowing, crawling, grazing and tunneling in the sediments.

Man made Causes of Coastal Erosion

i. Impact of Tourism : Digha coastal area is the second highest revenue earning tourist spot of West Bengal, next to Darjiling. As a tourist spot, Digha has gradually developed and the area witnessed an unprecedented construction within the range of a few hundred meters behind the sea wall. Many multistoried hotels were built within a short distance, especially in Old Digha.

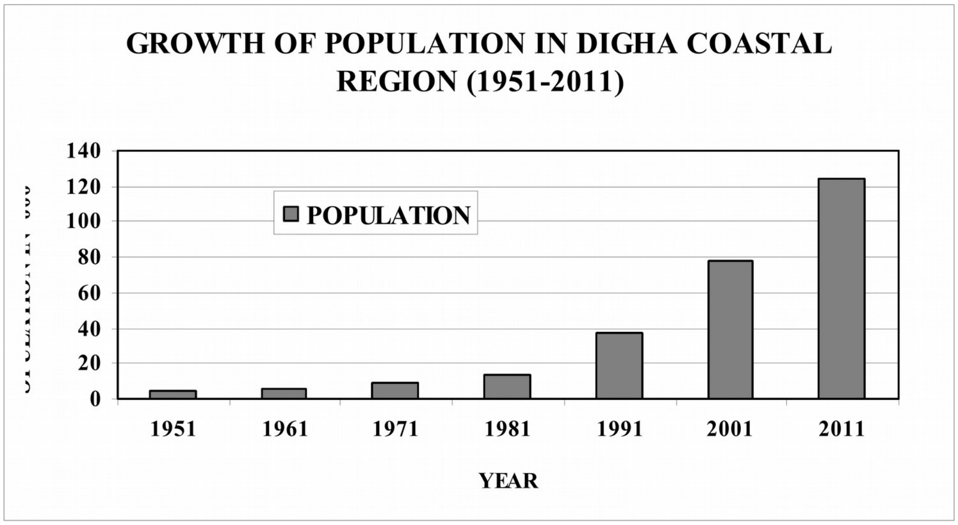
Table 2: Growth of Hotels and Holiday Homes in Digha Coastal Region

Place	1960-'69	1970-'79	1980-'89	1990-'99	2000-'09	2010-'12	Total
Old Digha	8	11	51	53	77	25	225
New Digha	1	3	11	20	56	28	119
Shankarpur	0	0	0	4	26	12	42

Source of Data: Department of Environment, Govt. of West Bengal and Field Survey

The indiscriminate installation of heavy tube wells into the dune bank has led to the collapse of subsoil layers and the resultant subsidence and seepage of saline water into the drinking water. The development of Mandarmani tourist complex in the Dandonpatrabar, Purusottampur stretch violating the Coastal Zone Regulation Act is another threat to the coastal environment in general and biodiversity in particular. The Coastal Regulation Zone Notification violations affect the security and future of thousands of traditional fishing families which are threatened with physical and ecological displacement by industrialists and developers looking for short term financial gain rather than long term ecologically sustainable use.

ii. Growth of Population: This zone supports many different types of livelihood e.g. fishing, tourism, manufacturing, farming, and other industries are all very important to the coastal areas, but without proper planning, damaging conflicts emerged which are destroying the very resources that support these economic activities. A major contributor to marine environmental problems is human population growth and excess consumption of resources. This coastal region faces the potential for catastrophe from the combination of coastal population growth, coastal subsidence, land-use changes in the catchment area, and global climate change.



Source of Data: Based on District Census Handbooks and Field Survey 1951-2011

Fig. 2

Permanent and Temporary fishing villages have been constructed on the dune slope which destroyed the stability of dunes in Dandonpatrabar, Junput, Digha Mohona fish landing centre. The population of Digha coastal area was 4569 in 1951 which increased to 124568 in 2011 (Fig.2). Rapid expansion of tourism and fishing industry stimulated the growth of population in this area.

iii. Construction of Sea-Wall and Embankments: A 4 km long bouldery embankment and concrete seawall had been constructed by the State Government to protect the sea resort of Digha at a total cost of Rs. 50.5 million rupees during 1980's. But this measure did not prove to be yielding any effective benefit against erosion of the coast. Hundreds of coastal families and the hotel owner are suffering from panic of massive coastal erosion within a couple of years as the trend of erosion continues unchecked particularly in the areas immediately adjacent to the constructions. In many portions, construction of bouldery embankments and revetments in front of the seawall was proved to be of no use even within a span of one or two years time chiefly during the cyclonic storm events. In addition to the Government endeavour, Digha Fishermen and Fish Traders Association also spend every year some hundred thousands rupees for protecting the Digha Mohona (mouth of Digha river) area by building parallel-to-shore dykes made of sand-filled bags.

All these constructions have strong detrimental effects on the coast as these accelerate the erosive power of the waves. Measurements show that after the construction of seawall, the rate of retreat of the dunes is as high as 16 to 18m per year that was only 11m per year in 1980s before the construction.

Effect of Environmental Degradation

i. Coastal Pollution: Waste disposal from Digha's growing tourism industry generating pollution is affecting fisheries adversely. In 1996, the Public Health Engineering Department of the Govt. of West Bengal had undertaken a project to collect all the wastewater discharged by hotels in Digha and treat it before discharging into the sea. This sewage treatment system has proved to be completely ineffective. Kolaghat Thermal Power Plant on the bank of Rupnarayan releases hot effluents and coal burnt ash into the estuarine system. Over half of the Digha coastline is at significant risk from development-related activities. Some of these activities are:

a. Conversion of tropical coastal forests to hotels, markets, shops, fish and shrimp farms which are in the direct path of monsoons, tropical storms and tsunamis

b. Pollution of sea water from tourism activities, fish marketing and throwing of garbage c. Releases of untreated or partially treated human sewage in the sea (between one-third and two-thirds of the human waste generated in this area is not even collected).

ii. Coastal Erosion: Historical records show that during the period 1877 and 1965, Digha shoreline of Midnapore coast moved inland by 970 metres with an average retreat of 11 m/ year. The rate of shoreline retreat has been increased within the short term period between 1965 to1995 by 525m with an average retreat of 17.5 m/ year. This can be confirmed by damaged sea wall, destruction of the concrete wave breakers and many abandoned houses. The West Bengal Govt. constructed 4.7 km long sea wall with laterite stones to prevent such erosion in between 1972 and 1988 in the east west part of Digha. The sloping face of the sea wall touched the upper part of the beach plain. The sea wall does not cover many erosion prone areas to the east of Gobindabasan village, a stretch of 2 km up to Digha estuary. It was also noticed that the beach was steepened considerably after the construction of the sea wall, as compared to the pre construction period.

Coastal erosion, or coastal instability, threatens life, property and businesses and puts people living near cliffs and shorelines at risk. The great concentration of national resources in coastal zones makes it imperative that coastal change is well understood.

iii. Decreasing Fish Landings: The conversion of mangrove to aquaculture results in destruction of mangrove flora and fauna due to changes in the drainage conditions, nutrient availability, as well as being adversely affected by run-off from ponds and channels. It may kill the prawns or fish directly by poisoning them. It has observed that the total marine fishing landing mainly in Digha coastal region are sardine, hilsa, coila, pomphret, croakers, Bombay duck, catfish (total 37 species). There have been catastrophic changes. Hilsa which used to constitute about 70-80% of total fish landings is disappearing. Changes in salinity and hydrology cause large shoals of hilsa to congregate near the head of the Bay, but they do not enter the coastal region. Instead marine catfish have become dominant here.

iv. Coastal Flood: The coast provided natural protective structures to guard against coastal flooding. There were physical features like gravel bars, sand dune systems and ecosystems such as salt marshes and forests which provided significant protection against storm waves, tsunamis and shoreline erosion through their ability to attenuate wave energy. Coastal flood can result from a variety of different causes including storm surges created by storms like tropical cyclones, rising sea levels due to climate change and by tsunamis.

Table 3: Flood Hazard Zones of Digha Coastal Region

FLOOD HAZARD ZONE	LOCATION
HIGH (8.02%)	SUBARNAKHA RIVER, INLET & MARSHY AREAS AROUND DIGHA, SANKARPUR, PURUSHOTTAMPUR, MANDARMONI & HARIPUR
MODERATELY HIGH (26.76%)	NEAR THE HIGH HAZARD ZONES, ADJACENT TO THE EMBANKMENTS
MODERATE (34.13%)	FLOOD PLAINS OF SUBARNAREKHA, RASULPUR RIVER AND OTHER LOWLAND AREAS OF INTER-DUNAL SPACES
MODERATELY LOW (23.24%)	INTER-CHENIER DEPRESSIONS AND WEST OF SUBARNAREKHA RIVER
LOW (7.85%)	MIDDLE PART OF THE STUDY AREA WHICH ARE MAINLY COVERED BY THE ELEVATED CHENIER PLAINS

Source of Data: Based on Field Survey

This is largely a natural event, but human influence on the coastal environment can exacerbate coastal flooding. During cyclonic storms the wave height exceeds the elevation of the land because there is no natural barrier i.e. dune system and vegetation in most places. Engineered protection structures along the coast such as sea walls alter the natural processes of the beach, often leading to erosion on adjacent stretches of the coast which also increases the risk of flooding. Breaching of barriers in many places allows the sea water to extend inland.

Conclusion

The coastal zone under consideration is under severe environmental threat. The State Government has a master plan to develop the Digha sea resort and adjoining areas in near future. There is a pressure of developing the area with a view to make it more attractive for recreation, fishing and tourism purposes. All these will simply trigger urban development-conservation dilemma to this region, so typical of coastal zone of developing countries.

Annual afforestation in the erosion-prone regions should be given the first priority to save the coast. erosion. Terracing is an extremely effective means of erosion control, which has been practiced for thousands of years by people all over the world. Windbreaks (also called shelterbelts) are rows of trees and shrubs that are planted along the edges of agricultural fields, to shield the fields against winds. In addition to significantly reducing wind erosion, windbreaks provide many other benefits such as improved microclimates for crops (which are sheltered from the dehydrating and otherwise damaging effects of wind), habitat for beneficial bird species, carbon sequestration and aesthetic improvements to the agricultural landscape. Traditional planting methods, such as mixed-cropping (instead of monocropping) and crop rotation have also been shown to significantly reduce erosion rates.

Natural dunes should be given protection by creating obstruction across the path of wind. Artificial simulation of dune growth includes creation of sand fences, brush barriers and plantation of dune vegetation. These would help stimulation of dune growth. A constant vigil is to be established to prevent grazing and fodder collection from dune fields. Artificial dunes may be created where there is no natural dune or where long stretches of dunes are breached. But the imported dune materials must corroborate to the texture and composition of the adjoining beach material.

Beach mining and transportation of beach sand are to be stopped by legislation. Such activities not only modify the local beach profile but also disturb the equilibrium of beach sand budget.

Quick repairing work should be undertaken when a portion of the seawall or embankment is damaged. Tardy repairing not only enhances further erosion but also involves more cost of repairing at a later time.

In order to mitigate pollution of coastal waters, the use of multiport diffusers at the end of the discharge pipes should be extended long from land-water interface. Throwing of garbage on the beach should be stopped immediately.

A mass awareness programme with an aim to save the coast should be advocated as a measure of conservation strategy.

References

1. Annon.2005. Studies on Bio-Resource Assessment and Management of Degraded Mangrove Ecosystem of Midnapore Coast West Bengal, Ministry of Environment and Forests, Govt. of India, pp. 1-99.
2. Bhakat, R.K., 2001. Coastal Dunes of Digha, India – A Plea for Continued Protection. Indian Journal of Geography and Environment. 6 : pp. 54 - 60.
3. Chakraborty, S.K.2010 Coastal Environment of Midnapore, West Bengal : Potential Threats and Management, Journal of Coastal Environment, Vol.1, No.1, 2010, pp. 27-40.
4. Chaudhiri. S., 2004: Coastal Process and Morphology, pp. 9- 29.
5. DDA: Digha Development Authority, 1997: Land use and Development Control Plan 1995-2011, Urban Development Department, Govt. of WB, pp. 73 .
6. Department of Tourism, WB, 1996: Proposed Tourism in Digha, pp. 5-21; 24-31.
7. Geological Survey of India, WB, 1995, Project-13: A Report on the Coastal Zone Management Plan of Digha Planning Area, Medinipore District, West Bengal, pp.1-25.
8. Govt. of WB, 1994: Coastal Erosion in and around Digha, pp. 6-12; 24-32.
9. Maiti S; Bhattacharya A.K: Shoreline Change Study Using Remote Sensing Techniques Along Midnapur Coast, West Bengal, India.
10. Mukherjee ,A. D. and Chatterjee, S. 1997. Coastal Erosion and Accretion at and around Digha in Medinipur District of West Bengal .Indian Journal of Geography and Environment. 2 : pp. 1- 11.
11. Niyogi. D, 1970: Geological Background of Beach Erosion at Digha, West Bengal, pp.1-36.